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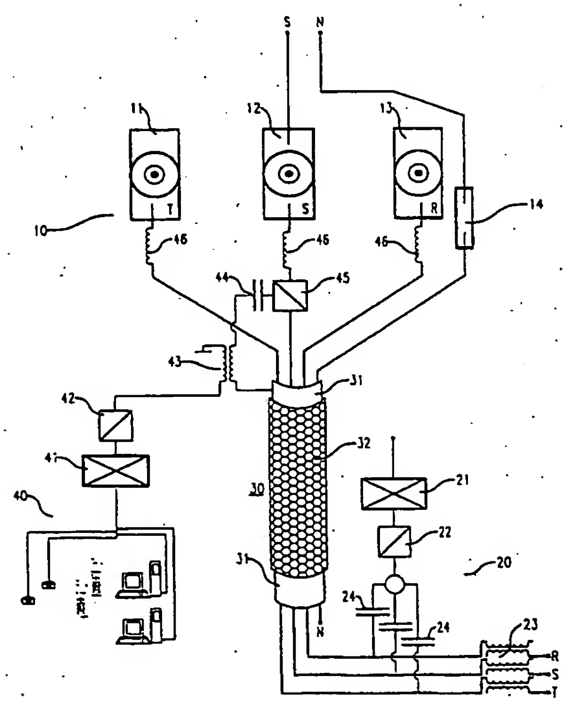

(57) Abstract: A telecommunication system comprises primary and secondary telecommunication means (21, 22) which through interposition of a telecommunication connection are mutually linked together. In this case the telecommunication link comprises a power cable (30), for instance from a network for electricity distribution. Such a power cable (30) comprises an external jacket (31) which at least encompasses one power conducting lead (R, S, T, N). The lead (S) is coupled to the telecommunication means (21, 22, 40) in order to transfer the telecommunication signal. In conformity with the invention the telecommunication means

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(21, 22, 40) are coupled with aforementioned lead (S) and with the external jacket (31) of the power cable (30) in order to present the telecommunication signal in between them. Thus a high quality asymmetrical signal transport is obtained which enables the presentation of telecommunication along an existing electricity network.

Telecommunication system

The present invention is related to a telecommunication system which encompasses primary and secondary telecommunication means which are mutually connected to each other, whereby the telecommunication connection comprises a power cable, consisting of an external jacket which encompasses at least one power conducting lead, which lead is coupled to the telecommunication means in order to convey the telecommunication signal.

Such a telecommunication system is suitable in particular for either public or non-public electricity companies which usually have an extensive and finely branched electricity distribution network at their disposal regarding the supply of electricity to households, companies and institutions. In principle, the power cables out of which such a network is composed, are, in addition to the supply of electricity, also suitable for telecommunication services which enables multiple exploitation of the network. In this context one should not only think of telephony but for instance also consider the various forms of telemetry and data communication applications like Internet. Added to this, the electricity distribution is increasingly handed over to various private parties, as a result of which an additional requirement arises to take the meter reading remotely. It may be quite clear that such readings of meters preferably should occur along the distribution system networks as owned by the aforementioned parties.

Up to the user, the electricity distribution network is composed of power cables, which vary from high-tension cables for electricity distribution along long distances to power cables between the distribution centre and the meter cupboard of the end-user. The latter category of cables usually consists of a (ground) cable with a metal external jacket within which a number of leads are mounted which provide the electricity supply at the common network voltage. The external jacket protects the leads against mechanical influences from the outside.

With respect to an existing telecommunication system of a type as referred to in the beginning, a telecommunication signal is administered between two of these leads. On

the end-user side this signal is filtered away from the leads and routed to the telecommunication means. A symmetrical signal transfer along the leads is thus provided for.

The drawback of such a system however appears to be the weakening and distortion of the signal during the transport along the wires of the distribution network. Because of this, the signal is often only transmitted imperfectly which is unacceptable, particularly in view of telemetry and data communication. The design of this invention is the provision of a telecommunication system of the type as referred to in the beginning, in which this is avoided at least to an important extent.

In order to attain the objective set forth, a telecommunication system of the type as referred to in the beginning and further in accordance with the invention, is characterised by the fact that the telecommunication means are connected to the aforementioned lead and the external jacket of the power cable in order to administer the telecommunication signal between them. Thus the signal is not administered mutually between leads but always between a lead and the external jacket. Because the external jacket is actively involved in the transfer of the telecommunication signal, the power cable responds, as it were, like a coaxial cable with a relatively stable impedance which enables an asymmetrical signal transport. In addition the external jacket provides an adequate screen against external interference's through which a remarkably smaller distortion of the signal is experienced in comparison with the existing system.

Frequently the public part of the power cable, leading to the end-user, is composed of a number of leads which are not utilised altogether by the average user. The power cable, terminating in the meter cupboard of the end-user in the Netherlands for example, is composed of four leads, namely a neutral and three phases. Usually only one of these phase will be connected whereby the specific phase being connected may differ from end-user to end-user in order to spread the load through them. In order to ensure that a co-transported telecommunication signal can be received by each end-user, the configuration of preference in accordance with the invention is characterised by the fact, that the power cable is composed of a number of power conducting leads which are

capable of carrying in principle identical telecommunication signals, such with respect to the external jacket, and that at any rate one of both telecommunication means is coupled to all these leads in order to exchange the telecommunication signal with all three leads. Because at least one side of the telecommunication signal is thus administered to all leads, it will always be available at the other side of the telecommunication path..

Superimposing the telecommunication signal onto the electricity network may in itself be accomplished in various ways. A special configuration of the telecommunication system according to the invention is characterised in this respect by the fact that at least one of the telecommunication means is coupled capacitively to at least one lead of the power cable by the interposition of at least one capacitor. In this case the telecommunication signal is capacitively transferred to, or extracted from the power cable. A configuration of preference of the telecommunication network in this respect is furthermore characterised by the fact that the telecommunication means are coupled to at least one lead of the power cable by the interposition of at least two capacitors at different locations. On account of the aforementioned coupling of telecommunication means onto the power cable, using at least two capacitors at different locations, two similar telecommunication signals with a mutual phase differential will be transferred jointly. This phase differential will depend on the covered travel distance of both signals as caused by the different locations where the capacitors act upon the power cable. This phenomenon may be exploited profitably by intercepting both signals and using the strongest one of both for recovery of the information contained in it. Such a technology is also referred to as 'antenna diversity'.

A further and special configuration of the telecommunication system according to the invention is characterised the fact that at least one of the telecommunication means is coupled radiographically to at least one lead of the power cable by the interposition of an antenna. In this regard a completely uncoupled signal transfer has been chosen between the telecommunication means and the network of which the power cable forms part. A configuration of preference of the telecommunication system in accordance with

the invention is characterised by the fact hat the antenna is composed of a dipole antenna of which the radiation field is oriented, at least in principal, along the axial direction of at least one lead of the power cable. By thus arranging the field of the dipole antenna in the axial direction of the power cable, a greater overlap and consequently coupling-in will be obtained then would be the case with the antenna aligned otherwise, thus enhancing the quality.

A further and special configuration of the telecommunication system according to the invention is characterised the fact that at least one of the telecommunication means is coupled to the power cable by the interposition of a band-filter and that the telecommunication means are capable of operating within the frequency range as dictated by the band-filter. The band-filter only permits the passage of a specific frequency range to which the applied carrier waves of the telecommunication signal as well as the communication means are adjusted. By thus operating within a strict frequency range, it is possible to exclude signals outside of this frequency domain, thus enabling the undiluted utilisation of the telecommunication signal. A further configuration of preference in accordance with the invention is characterised in this context by the fact that the frequency range lies at least almost between 5 and 25 MHz. With regard to at least many electricity distribution networks, this frequency range has not yet been utilised, contrary to lower frequencies which sometimes transfer signals already now. On the other hand, higher frequencies are subject to more weakening during transfer and, among others for this reason, are less attractive.

Contrary to very high frequencies, the above indicated frequency range is yet relatively sensitive to distortion caused by interference. Among others in view of this, a further configuration of preference of the telecommunication system in accordance with the invention is characterised by the fact that the telecommunication means are capable of operating according to the DECT protocol. DECT stands for Digital Enhanced Cordless Telephony and is described extensively in the pertinent standard as promulgated by the European Standardisation Institute (ETSI) which, as far as required, is assumed to have been included herein. The underlying protocol of this standard in the context of the

present invention is however also applicable outside of the wireless telephony and extremely suitable for dealing with interference's because it is based on the 'make before break' principle. If too much interference is present with regard to sustaining the signal within a certain frequency band, then this protocol will first search for a better frequency band in order to possibly continue the signal along this band before cutting the connection. Thus the available bandwidth is optimally utilised for transfer of the telecommunication signal. This protocol lends itself for both telephony and data transfer and consequently is suited for all conceivable application options.

A further measure to suppress high frequency noise and other high frequency interference's is offered by yet another configuration of the telecommunication system in accordance with the invention which is characterised by the presence of at least one suppression coil in the power cable, which is capable of suppressing the high frequency interference's at least partly.

Regarding a hybrid network of the type, as described next, it is extremely important that the telecommunication equipment, which usually is powered by low tension, is de-coupled from the high-tension side of the electricity system. For this purpose a special configuration of the telecommunication system in accordance with the invention is characterised by the fact that at least one of both communication means is coupled to a secondary winding of a transformer, of which the primary winding encompasses the power cable. Through the interposition of the transformer, an effective separation is achieved between the telecommunication network and the power network but still leaves the option for the passage of a high frequency telecommunication signal, and thus the telecommunication means may be operated in a safe manner.

De invention will now be explained more closely by means of a design example with a drawing to match. The drawing in figure 1 shows:

a schematic design example of a telecommunication system in accordance with the invention.

The drawing is purely schematic and not drawn to scale. Some dimensions in particular have been presented quite exaggerated for the purpose of clarity.
Similar parts are indicated as much as possible by the same reference numeral.

The telecommunication system in figure 1 is based on an existing or non-existing electricity distribution network which is composed of a number of power cables along which electricity is supplied to households, companies and institutions. The section of the system as shown, is installed in the final part of the distribution network onto which the end-users are directly connected. In this case the network terminates in meter cupboard 10 with the end-user. Usually a few hundred end-users are thus connected by means of individual power cables 30 to a common sub-centre 20 which is typically located at a remote distance of some 300 metres. The sub-centre is fed from the common feeders which operate at a higher voltage.

The power cable running to the end-user is composed of four leads, namely three phases R, S and T, each of which is carrying an alternating voltage of around 220 Volt (RMS), and a neutral N. The leads R, S. T and N are surrounded by a mechanical protection in the form of metal jacket 31. This jacket protects cable 30, which usually is buried at a certain depth beneath ground level, against light digging activities and other mechanical influences from the outside. Furthermore, the circumference of the jacket is covered with synthetic insulation 32, for instance polyvinylchloride (PVC) or polypropylene (PP). This insulation not only ensures the electrical insulation of the cable but also provides a hermetical barrier against moisture.

Inside the meter cupboard 10, three master fuses 11, 12 and 13 are to be found. In a simple household only one will be connected to cable 30. Neutral N is directly connected by means of a connection block 14. Thus the household has one phase S and neutral N at its disposal, which through the interposition of the customary fuse box, not included in the drawing, are distributed further to various outlets and other connection points in the house.

The distribution network as shown is not merely suitable for the electricity supply but also lends itself for telecommunication, in principle on behalf of whatever means 40 of telecommunication, as indicated schematically. The telecommunication means on the side of the user are coupled to the power cable 30 through interposition of a DECT interface 41 and a frequency converter 42. Furthermore, this part of the communication network is de-coupled from the power lead by means of transformer 43 in order to buffer the impedance difference between both sides of the network. Inside the user domain 40 of the network the standard impedance is 50 ohms, whereas the signal in the power domain in practice experiences typically an impedance between 3 and 10 ohms. Thanks to the interconnection of transformer 43 both domains are nevertheless capable of communicating with each other without any problem.

DECT stands for Digital Enhanced Cordless Telephony and is based on a standard communication protocol, promulgated by the European Standardisation Institute (ETSI) and laid down as such (ETS 300 175). Although the name suggests otherwise, the protocol lends itself in principle to all forms of telecommunication, so not only for wireless telephony but for instance also for wired telephony, telemetry and data communication. The DECT protocol in this example is implemented on carrier frequencies of some 5-25 MHz with which the telecommunication signals are transported through the network. Because DECT is based in principle on operating at frequencies around 1880 MHz, the frequency conversion devices 42 provide the required frequency conversion. In this example the following frequency scheme has been assumed:

DECT-kanaal	dragerfrequentie
9	6,912
8	8,640
7	10,368
6	12,096
5	13,824
4	15,552
3	17,280
2	19,008
1	20,736
0	22,464

DECT is a protocol designed for handling interference's and other disturbances in conduits. In case of prohibitive interference levels of the signal, the so-called 'make-before-break' mechanism provides for diversion to another channel for continuation of the signal. Similarly DECT adapts itself to the communication traffic in the network of that moment whereby the frequency bands are allocated automatically without a requirement for continuous advance planning. Thus DECT provides a communication signal of a significantly better and more reliable quality than a normal open line connection. This is in particular of advantage regarding the present system because it is not operated at the usual high frequency of around 1880 MHz but at the carrier frequencies of 5-25 MHz which are considerably more sensitive to interference.

According to the invention the telecommunication signal is administered to at least one of the leads R, S, T and N of the power cable and metal screen 31. For this purpose the communication means 40 are routed to meter cupboard 10 and, through the interposition of a capacitor 44 and a band-filter 45, connected to one of the phases S and screen 31. Furthermore, band-filter 45 selects the aforementioned frequency range of 5-25 MHz and passes this on to the communication means exclusively. The lower bands of 0-5

MHz are passed on to meter cupboard 10 and are thus still available for simple telemetry applications, such as switching and reading out of the electricity meter as present in the cupboard, but not included in the drawing. Signals at frequencies above 25 MHz are not passed on by filter 45. In addition the suppression coils 46 in the leads R, S and T adequately suppress any high frequency (harmonic) signal component which otherwise might interfere with the proper signal. Capacitor 44 ensures the desired exchange of the communication signal with power lead S and in addition the de-coupling of user domain 40 from the network power domain. This latter feature is particularly important In view of safety.

By thus using mechanical screen 31 and at least one of the leads for asymmetrical transport of the telecommunication signal, the power cable acts as co-axial cable and accordingly provides by itself electrical shielding of the telecommunication signal against interference's. A considerable quality gain is thus obtained in comparison with existing systems when attempting the transfer of telecommunication signals along an electricity network. The impedance of the power cable is relatively stable with in practice a value between 3 and 10 ohms. Through de-coupling thanks to transformer 43, a possible impedance mismatch is buffered and the communication means 40 may nevertheless be operated with connections with a more common impedance of 50 ohms.

Sub-centre 20 contains an arrangement of transformers 23 which take care of the desired voltage conversion within the power network, from high-tension voltage to the desired public voltage of the network. In accordance with the invention, the sub-centre also comprises the interposition of a frequency converter 22, a transformer 23 and a capacitor 24, through which the telecommunication signal is exchanged with power cable 30, on the understanding that in this case all phases R, S and T inside cable 30 are connected in parallel in order that the telecommunication signal is available with respect to every phase inside every meter cupboard 10. The telecommunication signal is thus offered between the respective leads R, S and T and the common jacket 31 of power cable 30. Through interposition of a DECT interface 21, the sub-centre 20 is coupled to the network power plant. This may be achieved via the electricity network or via a

separate and specifically adjusted high quality telecommunication connection. Incidentally, the transformers 23 also act as suppression coils and thus absorb high frequency interference's, reason why a separate inclusion of suppression coils 46, contrary to the user domain 40, may be omitted. All in all and besides the distribution of electricity, telecommunication between different end-users within the network is also possible. Through an existing methodology, a network may be mutually coupled with one or more other networks which will enable communication between users of different networks.

Coupling of the telecommunication signal onto the power cable may in itself be achieved along different ways. The figures 1 through 5 present examples of this. The starting point of both figure 2 and 3 consists of a capacitive coupling while in figures 4 and 5 the transfer of the telecommunication signal with the power cable is achieved by means of a dipole antenna.

In figure 2 the telecommunication signal RF is administered via a common wire to four capacitors, respectively tapped from those, which are soldered or otherwise connected to the respective leads N, R, S and T of cable 30. Thus the DECT signal RF is available at all leads. In view of an adequate signal transfer and additionally a safe de-coupling between the low-tension signal RF and the power cable 30, the capacitors 24 to be used in this case, should be types with a relatively high capacity of at least ...mF. If desired, more of such capacitors could be used in parallel regarding each lead N, R, S and T.

An improved signal to noise ratio may be obtained through the usage of a so-called diversity principle, as depicted in figure 3. This implies that the telecommunication signal RF from different sources RF1 and RF2 is coupled to the respective leads N, R, S and T through individual capacitors. The position difference d between the capacitors results in a covered travel distance difference between both signals RF1 and RF2 and thus in a phase difference. At the receiver side, both signals RF1 and RF2 are utilised by continually selecting the strongest signal of both in order to maintain a higher signal to noise ratio and signal strength as would be the case with just one singular coupling. The

required electronics for this concept are commercially available and are therefore not explained in further detail in this document.

Instead of a capacitive exchange of the telecommunication signal with the power cable, an inductive exchange is also possible. For this purpose a dipole antenna 25 may be used for instance, ad depicted in figure 4. The dipole antenna 25 is positioned between the leads of the power cable 30 such, that the dipole field 26 of the antenna encompasses at least a part of the leads. The telecommunication signal RF is conducted to the antenna via a high frequency wire 27, respectively tapped from that, and thus exchanged with leads R, S, T and N through induction.

Although the design of figure 4 is feasible, preference is given to the design of figure 5 in which the orientation of the dipole antenna 25 in cable 30 differs with some 90||. Through this rotation of the dipole antenna 25, a greater overlap is obtained with the leads R, S. T and N and therefore a stronger coupling of the dipole field. It may be obvious that the signal strength benefits from this.

Although the invention will be explained in further detail by purely a number of design examples, it should be obvious that the invention is by no means limited to the presented examples. On the contrary, for the average professional there are yet many variations and appearances conceivable without the requirement to deviate from the scope of the present invention.

In general the invention offers a solution for telecommunication along an electricity distribution network.

Conclusions:

1. A telecommunication system, comprising primary and secondary telecommunication means which through the interposition of a telecommunication connection are mutually coupled, whereby the telecommunication connection comprises a power cable, consisting of an external jacket which encompasses at least one power conducting lead, which lead is coupled to the telecommunication means in order to transfer a telecommunication signal with the characteristic that the telecommunication means are coupled to both aforementioned lead and the external jacket of the power cable in order to present the telecommunication signal in between them.

2. A telecommunication system according to conclusion 1 with the characteristic that the power cable encompasses a number of power conducting leads which are capable of carrying an in principle identical telecommunication signal with respect to the external jacket and that at least one of both telecommunication means is coupled to all these leads in order to exchange the telecommunication signal with that.

3. A telecommunication system according to conclusion 1 or 2 with the characteristic that at least one of the telecommunication means is capacitively coupled to at least one lead of the power cable through the interposition of at least one capacitor.

4. A telecommunication system according to conclusion 3 with the characteristic that the telecommunication means are connected to at least one lead of the power cable through the interposition of at least two capacitors at different locations.

5. A telecommunication system according to conclusion 1 or 2 with the characteristic that at least one of the telecommunication means is radiographically connected to at least one lead of the power cable through interposition of an antenna.

6. A telecommunication system according to conclusion 5 with the characteristic that the antenna comprises a dipole antenna of which the radiation field, at least in principle, is oriented in an axial direction of at least one lead of the power cable.

7. A telecommunication system according to above conclusions with the characteristic that at least one of both telecommunication means is coupled to the power cable through interposition of a band-filter and that the telecommunication means are capable of operating within a frequency range as permitted to pass by the band-filter.

8. A telecommunication system according to conclusion 7 with the characteristic that the frequency range lies at least almost between 5 and 25 MHz.

9. A telecommunication system according to one of the above conclusions with the characteristic that the telecommunication means are capable of operating according to the DECT protocol.

10. A telecommunication system according to one of the above conclusions with the characteristic that the power cable is provided with at least one suppression coil which is capable of suppressing high frequency interference's at least partly.

11. A telecommunication system according to one of the above conclusions with the characteristic that at least one of both telecommunication means is coupled to the secondary winding of a transformer, of which the primary winding encompasses the power cable.

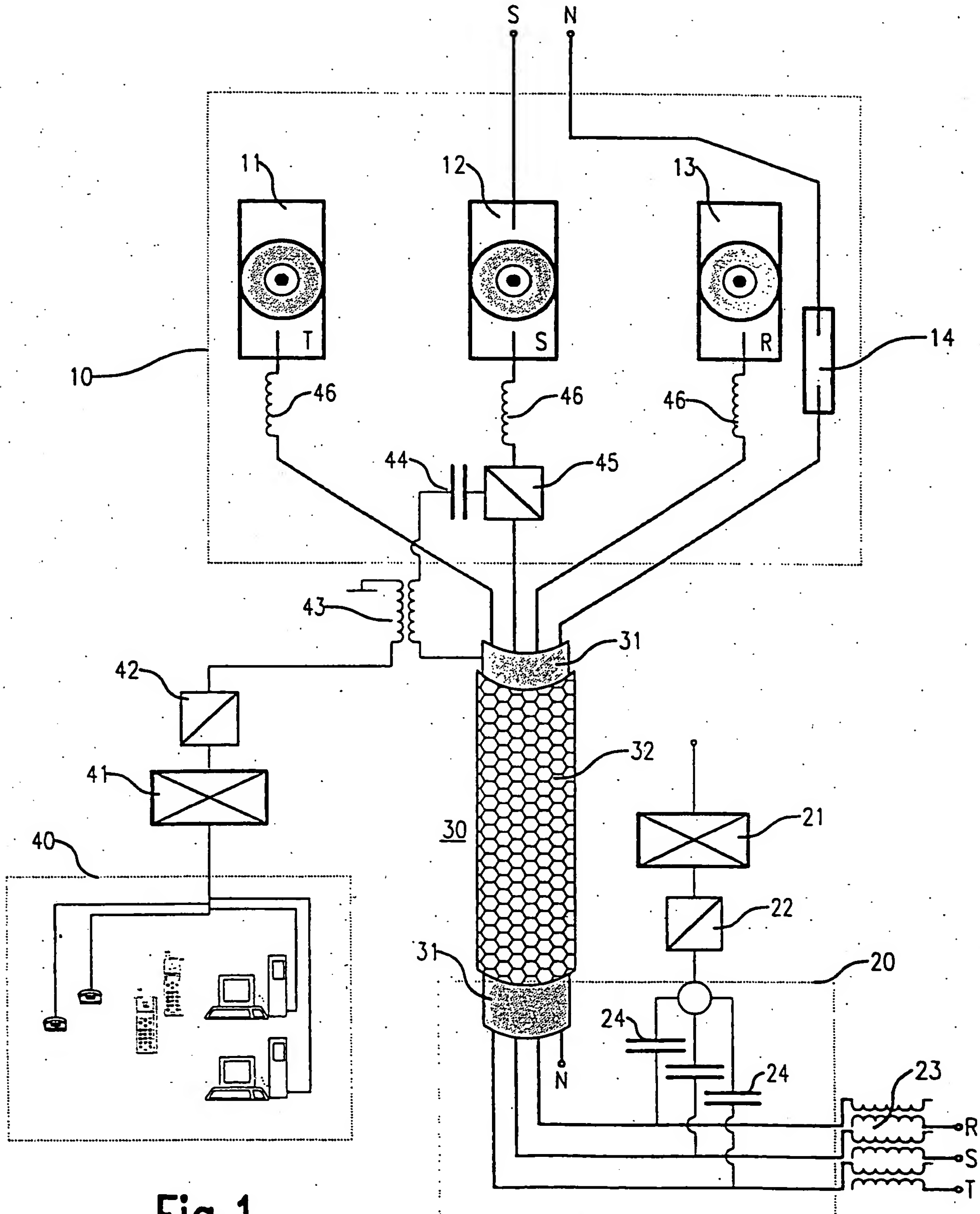
S
N
11
12
13
T
S
R
14
10
46
46
46
44
45
43
31
42
32
41
30
21
40
22
31
20
24
N
24
23
R
S
T

Fig.1

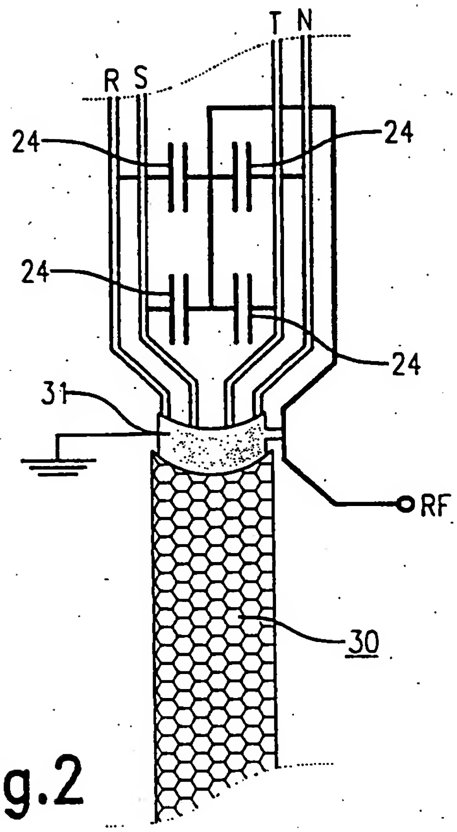
R
S
T
N
24
24
24
24
31
RF
30

Fig.2

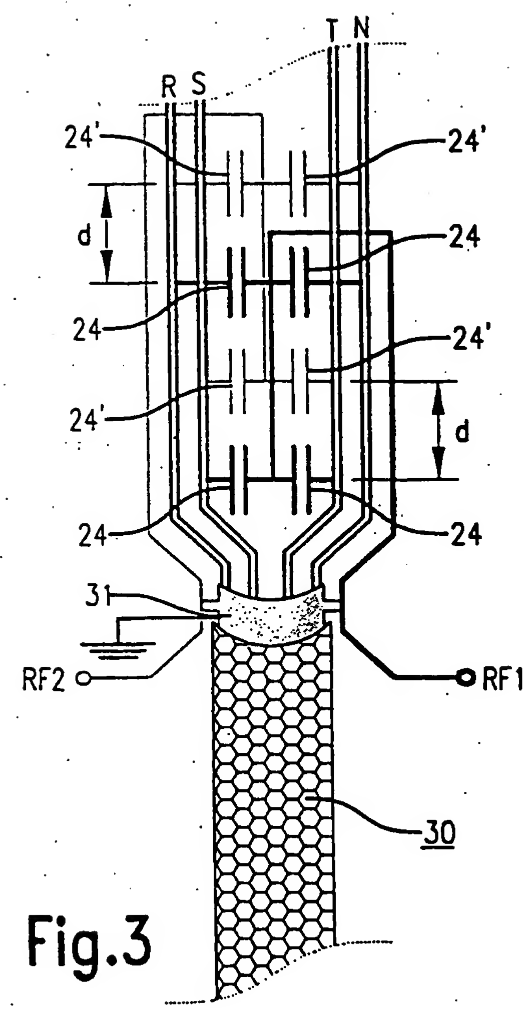
T
N
R
S
24'
24'
d
24
24
24'
24'
d
24
24
31
RF2
RF1
30

Fig.3

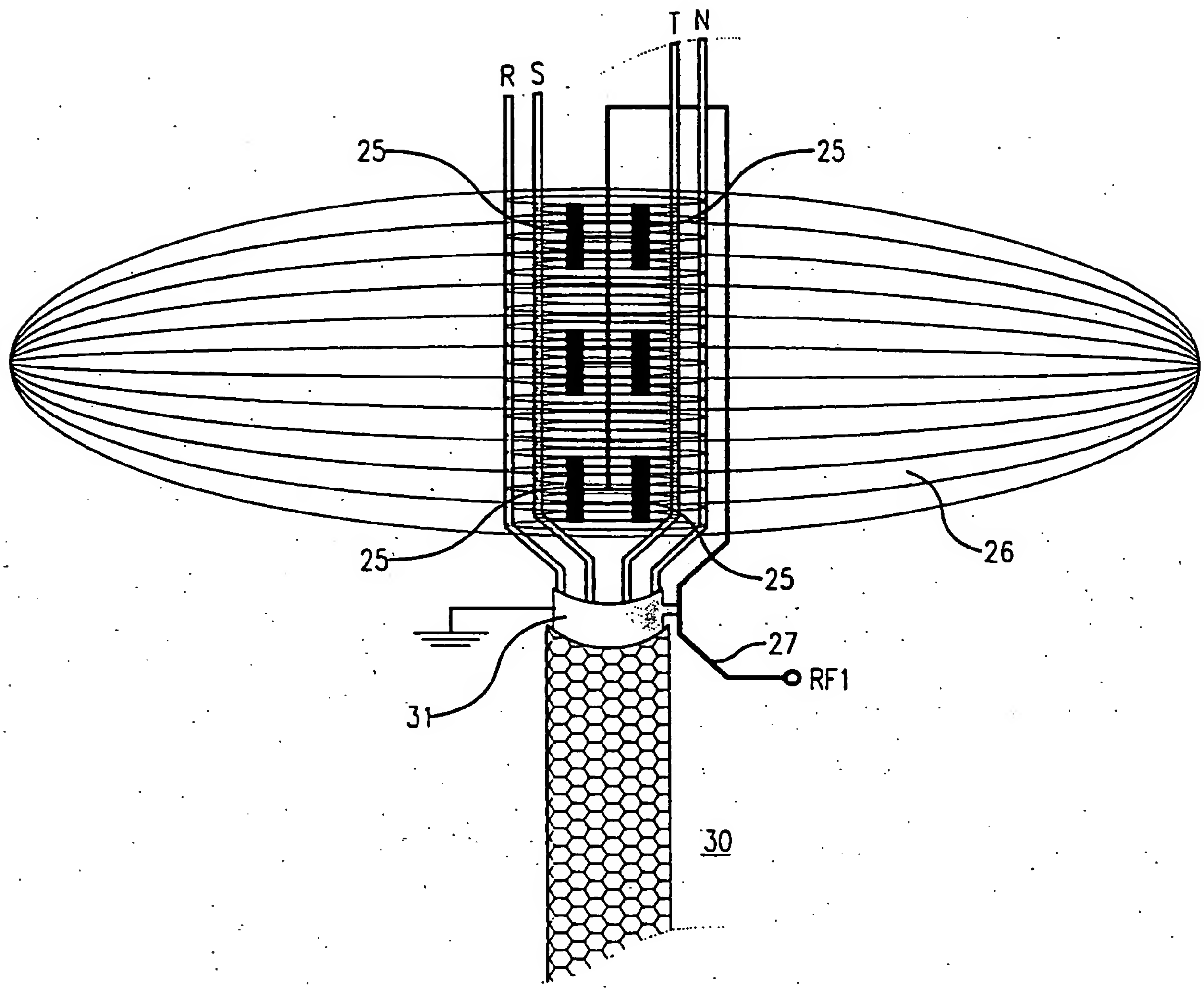

Fig.4

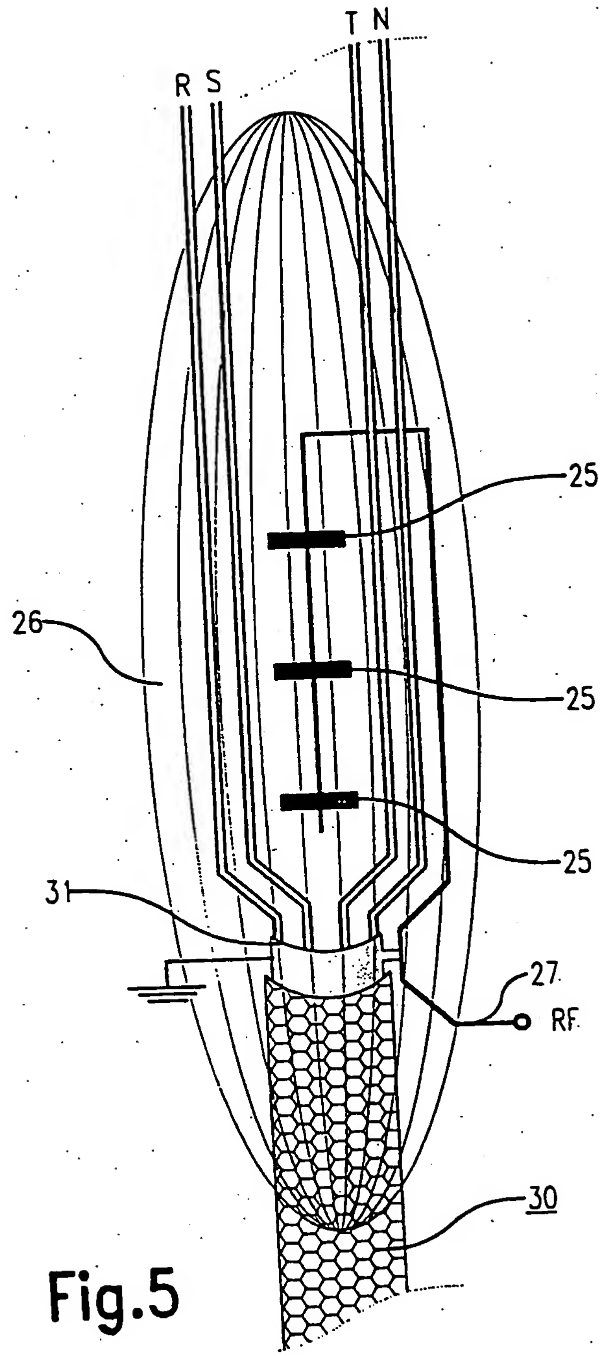

Fig.5